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The SpotOn™ Sprayer Calibrator, a Digital Flow Meter: Accuracy Evaluation and Use in Pesticide Safety Education Programs

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Abstract

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Keywords

application rate, calibration, flow rate, flow meter, Innoquest, SpotOn(™)

Disciplines

Agriculture | Bioresource and Agricultural Engineering

Comments

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The SpotOn™ Sprayer Calibrator, a Digital Flow Meter: Accuracy Evaluation and Use in Pesticide Safety Education Programs

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Abstract

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Tests confirmed that the SpotOn™ Sprayer Calibrator measures nozzle flow rate accurately, quickly, and easily. Pesticide safety educators can use this device to demonstrate the factors involved in nozzle flow rate, identify worn nozzles, and calculate a system's application rate.

Keywords: application rate, calibration, flow rate, flow meter, Innoquest, SpotOn™

Introduction

When setting up any spraying system, calibrating it, and checking its output during the spray season, operators need to measure nozzle flow rate. There are several ways to do this. One is to collect the liquid released by a nozzle in a predetermined unit of time, using a container designed to measure volume accurately. Another is to use a flow meter. Either tactic will allow an operator—or pesticide safety educator teaching clients how to configure and calibrate—to check the volume released by a single nozzle, compare a set of nozzles for uniformity and check for signs of wear, and calculate the output of a multinozzle system.

The “catch” method typically involves one 30- or 60-second collection per nozzle. In larger systems, this can be time-consuming, depending on the number of collection containers and helpers available. Mechanical flow meters are difficult to position properly and can only be used with cone or basic flat-fan tips.

Innoquest produces a digital flow meter (SpotOn™ Sprayer Calibrator), which is being marketed as a tool that applicators can use to accomplish the tasks described above quickly and easily. We set out to confirm claims that this device provides accurate, rapid results and is indeed easy to use. Following manufacturer's instructions, six universities tested the SpotOn™ Sprayer Calibrator. Details about these tests—including materials, methods, and results—are presented in the appendix of this article. In addition to

evaluating a specific device, this review discusses the pros and cons of using a digital flow meter and, in general terms, how such a device may be used in educational programs.

Discussion

Calibration is the process of determining how much material is applied to a test area. For sprayers, calibration measures the volume of finished solution or suspension the device is applying per unit area as configured. The calibration process involves measuring application equipment output and adjusting its application rate, if necessary, to ensure that label directions are followed. Two important calibration elements are:

1. The uniformity of pesticide output or release.
2. The application rate and the factors that affect it.

One of the factors that affect the application rate of a spraying system is flow rate. Flow rate is the volume of material released per unit time; for example, the amount of fluid that passes through a nozzle's orifice in one minute. Flow rate depends on orifice size and pressure. For liquid products, flow rate is often expressed in gallons per minute (gpm).

New nozzles should be tested to confirm their flow rate. Once a spraying system is in operation, nozzle flow rate tests should be done often to check for nozzle wear, damage, or obstruction. In addition, sprayers should be calibrated every time a different pesticide is applied if changing products involves changing nozzles, boom height, or some other factor that affects application rate. In addition, due to normal wear and tear, sprayers should be checked frequently and may need to be recalibrated often when in continuous use. Hence, having a quick but accurate way to check nozzle flow rate is extremely useful.

As a rule, pesticide applicators measure a nozzle's flow rate by collecting the fluid it releases for a prescribed unit of time, usually 30 seconds or one minute. This operation also allows applicators to ensure that each nozzle in a set or on a boom is releasing liquid in a uniform manner. Assuming an accurate volumetric device is used and read properly, catching released liquid for a prescribed unit of time and comparing output from nozzle to nozzle is an accurate method. However, this process can be time-consuming. For example, checking a field sprayer with a 120-foot boom and nozzles spaced 20 inches apart will require testing 73 nozzles. For single operators who collect the output from each nozzle for one minute, this process will take more than an hour—73 minutes per sprayer—plus the time needed to move along the boom and read the volume in a collection container 73 times. Even for a much smaller unit (for example, one with a 20-foot boom and 20-inch nozzle spacing), a single operator would spend 20 to 30 minutes checking 13 nozzles. Alternatively, if a team approach is used, the team will need a large number of accurately marked containers designed to collect and measure liquid ounces.

Using a flow meter to determine nozzle output may save time, especially if an operator is working alone or has a limited number of accurate containers with which to collect the liquid released by the nozzles in a large spraying system.

Mechanical flow meters are available. Although these devices provide rapid measurements, they are not widely used for several reasons. They can be difficult to put on, hold in position, and read. Also, they do not have a connection to fit all nozzle types.

The SpotOn™ Sprayer Calibrator, a digital flow meter, is a clear tube with a metal frame. It is designed to be placed under a nozzle and to collect the liquid released. It calculates output (in gallons per minute, ounces per minute, or liters per minute) based on the time it takes for water to collect in the container between two points. A diffuser pad reduces splash and turbulence from the spray stream so water does not strike the electrodes in the device directly. This would trigger the timer prematurely and thus cause a false reading. Independent tests showed that the SpotOn™ Sprayer Calibrator is easy to use and measures nozzle flow rate quickly and very accurately (see Appendix).

The major advantage of the SpotOn™ digital flow meter is its efficiency. In most cases, the SC-1 model, which is best for flow rates below 1 gpm, will give an accurate reading in about 10 seconds. A single operator can check 73 nozzles on a large sprayer in 15 to 20 minutes, compared to more than an hour using the volume “catch and measure” volumetric method. A person checking 13 nozzles could accomplish this task in less than five minutes (vs. 20 to 30 minutes).

For best results, follow manufacturer’s guidelines (see Appendix) regarding which device to use: model SC-1 for flow rates below 1 gpm or model SC-4 for flow rates between 1 and 4 gpm.

The biggest disadvantage is cost. Currently, a device for flow rates less than or equal to 1 gpm costs about \$150. A larger capacity model (1 to 4 gpm) is priced at about \$220. In addition, for accurate measurements, users must position the device so that all of the spray from a nozzle is collected. They must also hold it steady and at a proper angle for collection. Some skill and experience are needed to make accurate measurements.

The SpotOn™ digital flow meter is a useful teaching tool for pesticide safety educators because it can be used to:

- Demonstrate the factors involved in nozzle flow rate (the effects of orifice size and pressure).
- Compare output with values given in nozzle catalogs or technical bulletins.
- Identify worn, damaged, or plugged nozzles.
- Calculate total output (application rate).

Note that a rate control device will detect total system application rate but not differences between mismatched or worn nozzles. An accurate and easy-to-use digital flow meter allows educators to encourage people to calibrate and check spray equipment by showing them a quick but precise way to do this.

Regardless of the tactic used to calibrate or fine-tune a sprayer, the operator needs to confirm uniform output (and distribution) from each nozzle. Flow rate can be used to calculate system application rate. To use the SpotOn™ flow meter as a calibration teaching aid, review the factors involved in sprayer calibration—speed, nozzle spacing (in inches), and nozzle discharge (in gpm)—and illustrate how this device can be used to determine the latter (flow rate).

Summary

The SpotOn™ Sprayer Calibrator measures nozzle flow rate accurately, quickly, and easily. Although the device is relatively expensive, time is money for most applicators—and it is a big time saver. In addition, these devices can be used by pesticide safety educators to demonstrate the factors involved in nozzle flow rate, identify defective or blocked nozzles, show the relationship between nozzle flow rate and system application rate, and calculate a system's application rate.

Appendix

I. Materials used to evaluate the SpotOn™ Sprayer Calibrator (digital flow meter)

- Gram scale (Ohaus CS2000).
- Calibration collection container (TeeJet part # CP24034A-PP).
- SpotOn™ Sprayer Calibrator (model SC-1).
- Spray test device (see note below).
- Nozzles (see Table 1).

Table 1. Nozzles used in flow rate tests.

Nozzle type	Manufacturer	Orifice size		
XR	TeeJet	11002	11004	11006
TT	TeeJet	11002	11004	11006
ULD	Hypro	11002	11004	11006
AIXR	TeeJet	11002	11004	11006
TTJ60	TeeJet	11002	11004	11006

Note: Spray device should be capable of delivering a constant pressure and flow rate for the duration of each test run/collection. The maximum flow rate needed was 0.75 gallon per minute (gpm). The maximum pressure was 45 to 50 pounds per square inch (psi), measured as close to the tip as possible. Test devices included spray tables and single-nozzle spray stands.

II. Test locations and equipment used

- Iowa State University, spray table.
- Kansas State University, single-nozzle spray stand.
- Oklahoma State University, single-nozzle spray stand.
- South Dakota State University, spray table.
- University of Illinois, spray table.
- Virginia Tech, single-nozzle spray stand.

III. Methods

A. Set up and test the spray apparatus.

B. Use the gram scale to verify that each nozzle is delivering the correct volume by doing a test run at 40 psi with the test system. Compare the actual output to the specifications given on the manufacturer's chart; for example, each -02 orifice nozzle should release 0.2 gpm (26 oz = 737.09 g of water) at 40 psi.

C. For each nozzle/orifice and pressure treatment, test the flow rate using three methods—visual (container volume increments), scale (collect and weigh water released), and SpotOn™ electronic flow meter—with three replications each as described in Steps 1 through 3 below. Record every value; do not average.

Each team recorded 405 data points, 135 for each method: visual reading, time/catch and weigh, and SpotOn™ flow meter.

1. Visual reading: Use one TeeJet calibration container as described in the “Materials” section. Collect output as per a normal calibration procedure for at least 30 seconds. To ensure accuracy, designate one person to collect output and determine volume. Use the same start-and-stop signal and a consistent technique for moving the container into and out of the flow. After each test run, place container on a level surface. Use its increment marks to measure volume collected. Record the results. Use this container and the water collected “as is” for Step 2 (weighing output).
2. Time/catch and weigh: Use one TeeJet calibration container and a scale as described in the “Materials” section. Set the scale tare for that container. Collect output as per a normal calibration procedure for at least 30 seconds. To ensure accuracy, designate one person for collection. Use the same start-and-stop signal and a consistent technique for moving the container into and out of the flow with the sprayer running. After each test run, weigh the contents of each collection. Record weights in grams, and use an Excel spreadsheet to convert these values to gpm. Remove all of the water from the container before beginning another collection.
3. SpotOn™ flow meter: Take each data point from the electronic panel. Follow the methods described in the instructions for this device. Critical considerations include:
 - Ensuring that the diffuser is in place in the top of the cylinder. (This prevents any bouncing spray from hitting the electrodes, which may affect measurement accuracy.) See Figure 1.
 - Tilting the collector so that the spray will hit the sidewall just above the diffuser. See Figure 2.
 - Holding the device in place at the same tilt angle for the entire collection. (The SpotOn™ flow meter records the time it takes for the liquid to fill the container between its two electrodes.)

D. Record all 270 quantitative data elements in an Excel spreadsheet. See Table 2.

Table 2. Test parameters.

#	Nozzle type	Orifice size			Pressure at tip (psi)		
1	XR	11002	11004	11006	15	30	45
2	TT	11002	11004	11006	15	30	45
3	ULD	11002	11004	11006	15	30	45
4	AIXR	11002	11004	11006	15	30	45
5	TTJ60	11002	11004	11006	15	30	45

Template provided by R. E. Wolf.

- E. Evaluate the accuracy of each method by comparing the test flow rate with the nozzle manufacturer’s published or calculated flow rate for each type and orifice size at the specified pressures.

Figure 1. SpotOn™ device diffuser (blue arrow) and electrodes (red arrows).



Figure 2. Collecting technique.

IV. Results

Flow rate measurements taken with a SpotOn™ device corresponded closely to those derived by collecting water for a specific period, weighing it, and calculating flow rate. The same was true when compared to visual readings of volume increments on a collection container per unit time.

The SpotOn™ average reading was never more than 0.01 gpm different from the flow rate calculated based on the weight of water collected in a specific unit of time.

Table 3. Nozzle flow rate by nozzle type and measurement method.

Nozzle type	Nozzle flow rate (gpm)		
	SpotOn™ flow meter	Scale	Visual
XR	0.34	0.34	0.35
TT	0.34	0.34	0.35
ULD	0.37	0.37	0.38
AIXR	0.34	0.34	0.35
TTJ60	0.34	0.35	0.36

Note: Each value represents an average of 27 tests.

Table 4. Nozzle flow rate by nozzle orifice size and measurement method.

Nozzle orifice size	Nozzle flow rate (gpm)		
	SpotOn™ flow meter	Scale	Visual
11002	0.17	0.18	0.19
11004	0.34	0.35	0.36
11006	0.52	0.52	0.53

Note: Each value represents an average of 45 tests.

Table 5. Nozzle flow rate by pressure and measurement method.

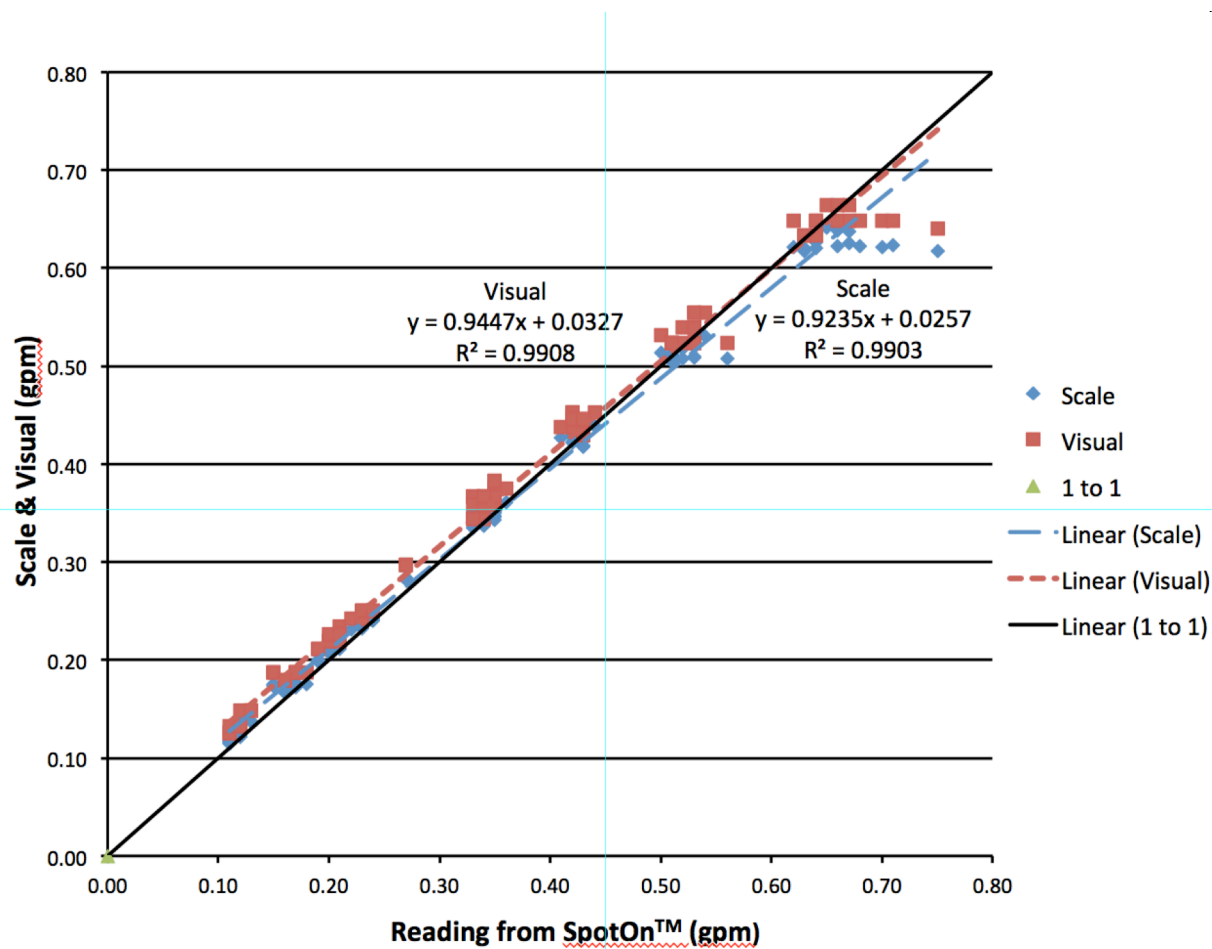
Operating pressure (psi)	Nozzle flow rate (gpm)		
	SpotOn™ flow meter	Scale	Visual
15	0.25	0.26	0.27
30	0.36	0.36	0.37
45	0.43	0.43	0.44

Note: Each value represents an average of 45 tests.

Table 6. Nozzle flow rate output comparison: average test measurements versus manufacturer's specifications by orifice size and operating pressure.

Nozzle orifice size	Operating pressure (psi)	Nozzle flow rate (gpm)			
		SpotOn™ flow meter	Scale	Visual	Mfr. standard
11002					
15		0.12	0.13	0.14	0.12
30		0.19	0.19	0.20	0.17
45		0.21	0.22	0.22	0.21
11004					
15		0.25	0.26	0.26	0.24
30		0.35	0.25	0.36	0.35
45		0.43	0.43	0.44	0.43
11006					
15		0.38	0.39	0.39	0.37
30		0.53	0.53	0.54	0.52
45		0.66	0.64	0.65	0.64

Note: Each value represents an average of 15 tests.

Figure 3. Flow rate graph sample: Virginia Tech data.

V. Acknowledgments

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VI. Further Reading

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